EFFECT OF VEHICULAR AND PEDESTRIAN TRAFFIC

ON

BACKSHORE VEGETATION AND BEACH DEVELOPMENT

Beach Impact Study, Padre Island National Seashore

final report prepared for

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ABSTRACT

Vegetative differences between heavily and very lightly trafficked beaches show that more beach traffic correlates with quantitative decreases in variety and density of plants and with declines of grasses relative to forbs. The vegetated portions of all beaches continue to grow in volume. However, this is at the expense of the more seaward (more trafficked) parts of the beaches and has lead to overall loss of total beach volume except where vehicular traffic is prohibited. The very lightly trafficked beach is the only study site wherein the entire beach to mean sea level has grown. The effect of these trends on resistance to storm surge erosion remains to be tested.

INTRODUCTION

Within Padre Island National Seashore there is a variety of degrees of beach usage and associated vehicular and pedestrian traffic. In 1974 a study was begun to measure differences in vegetation and beach sediment volumes which may be related to the different usage levels (Behrens, et al., 1975). The goal of the study was to determine if usage effects could affect the long term stability of the dune ridge against storm surge erosion.

To accomplish this goal vegetation was identified and beach profiles were surveyed over a 10 month period in four areas: NOTRAF where vehicles were prohibited (with the exception of one oil field maintenance vehicle) and pedestrian traffic was very light due to remote access; PEDTRAF where vehicles were prohibited but pedestrian traffic was moderate to heavy due to the proximity of a campground; VEHTRAF where both pedestrian and vehicular traffic were heavy due to an absence of restrictions; and SHELL where vehicular and pedestrian traffic were light because of the necessity of a four-wheel drive vehicle to reach the site. The distribution of vegetation was also mapped in all the areas except PEDTRAF. The effect of a storm surge on these contrasting areas was to be determined by repeating the beach profile and vegetation surveys after such an event took place. The locations of the study sites are shown in Figure 1. Maps of the plant distributions are shown in Behrens et al., (1975) Figures 8, 11, and 16.

The results of the initial vegetation surveys showed that the lesser trafficked beaches had a greater extent and variety of vegetation. The beach profiles showed a slow growth of all beaches

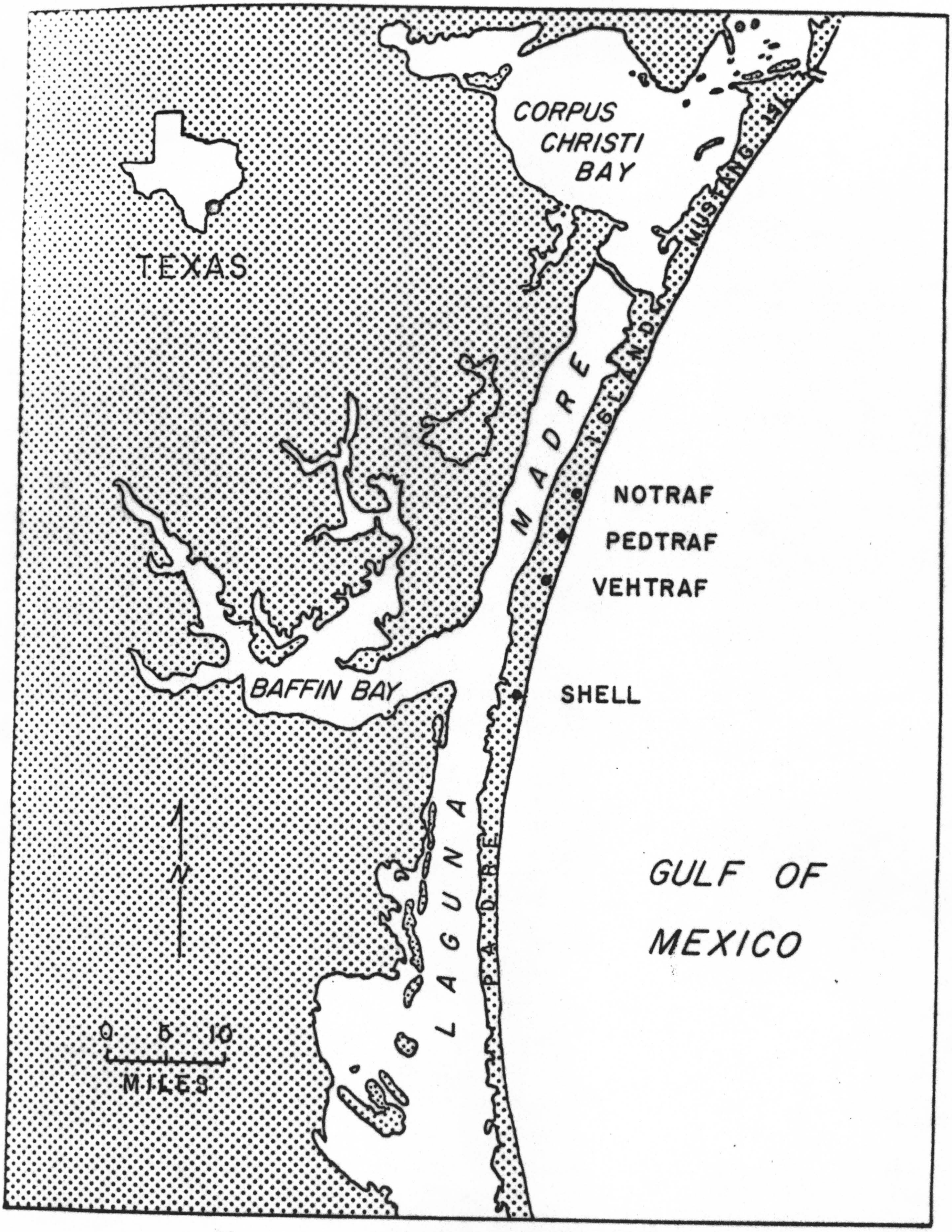

Figure 1. Index Map of the Study Sites.

but somewhat greater sand volumes and growth rates at the more trafficked sites. No storm surges occurred during the study period, so no effect was observed.

The present study was undertaken to continue to monitor the beach profiles and vegetation until a storm surge effect could be documented, to continue observations of the sand volume changes for long term trends which may be related to vegetation and usage differences, and to quantify more thoroughly the vegetational and sediment volume differences between the two most contrasting areas, NOTRAF and VEHTRAF.

PROCEDURES

Field Methods

In order to determine the mean and variance values for sand volumes and vegetation parameters, five additional profiles were located within 1,000 feet (350 m) of the original profile in each of the two more intensely studied sties, NOTRAF and VEHTRAF, and six additional profiles were located within 2.4 miles (4 km) of each original profile line. Beach profiles were surveyed with rod and level.

Vegetation was surveyed by two methods, point frame and quadrat. In the point frame method (Arny *et al.*, 1942; Rader *et al.*, 1962) a wooden frame is used to guide a thin rod from a point above all vegetation to the ground. As the point of the rod moves to the ground, a record is made of each item it contacts. The items identified were:

1. foliar hits - leafy parts of live plants; itemized to species;
2. aerial litter - any dead material such as old, nonvital stems,

grass blades, or nondeciduous leaves which are not on the ground;

3. basal hits - living grass culms, herbaceous stems or stoloniferous runners itemized to species;
4. ground litter - dead vegetative material lying on the substrate surface; and
5. bare ground.

The rod was lowered from ten positions spanning 27" on the frame at each station; and stations were located every 10 ft. along each profile.

In the quadrat method a one-quarter meter square (0.67 $ft.^2$) frame was dropped every ten ft. along each profile. The number of stems of each species within the frame was counted and summed for the profile. Stems were defined as culms for the grasses but as major lower branches for shrubbier vegetation wherein many leafy, upright, wind baffling branches extend from a single basal trunk. Individual runners were considered the stems of vines.

Data Processing

Volumes of sand in the beach are reported as cubic feet per linear foot of beach. This equals the cross sectional area from the surveyed surface down to an arbitrarily chosen datum. Two datums were used: mean sea level (msl), and a sloping surface approximating a theoretical hurricane beach (Behrens et al., 1975, p. 40). Volumes were calculated for both vegetated and unvegetated portions of the beach.

Point frame data were grouped into three categories, foliar, basal, and ground. The number of foliar hits for each species was divided by the total number of foliar hits along a profile to give percent composition of the foliage by species. Aerial litter was excluded in calculations used for the comparison of point frame and quadrat methods but was included in the comparison of sites. A basal percentage for each species was calculated likewise. Percent ground compositions were also calculated which included individual species counts where that was the lowest contact of the rod as well as ground litter and bare ground. These parameters reveal the compositional nature of the higher and lower portions of the vegetation and of the ground surface.

Whereas identical compositions may occur as sparse or dense populations, density values for each of the three categories were calculated by dividing the total counts of each item by the length of the profile in feet. For quadrat counts similar species percent compositions and plant densities were calculated for each transect.

METHOD EVALUATION

The quadrat method has generally been considered to be the more thorough (Oosting, 1956; Smith, 1966) but also the more time consuming. The methods are qualitatively different in that the quadrat method counts plants while the point frame method estimates aerial coverage. The stem definitions were designed to make the quadrat counts more representative of aerial coverage so that both may be related to sand entrapment. However, neither is a direct measure of root system development and related sediment binding. In order to evaluate the results of the two methods, various diversity and density parameters of NOTRAF and VEHTRAF were compared.

The number of plant species comprising one percent or more of the flora in the two areas, respectively, was 14 to 8 from quadrat data and 13 to 9 from point frame data. Of the eight most abundant species in NOTRAF, two determined by each method were not among the eight determined by the other method (Table 1). Of the six that occurred in both groups, none were ranked the same and some were as many as four ranks different. On the other hand, five of the top eight species at VEHTRAF occurred at the same rank by the two methods, and none differed by more than two ranks (Table 1). Figure 2 shows that the qualitative diversity difference between the two areas is shown equally well by the two types of data.

The chief differences in the results from the two methods are that rare species are not as well sampled by the point frame method. For example, at NOTRAF 13 species were identified as less than one percent abundant by the quadrat method while only six species were so identified by the point frame method. At VEHTRAF the respective numbers were three and one. Furthermore, in spite of the stem definitions used, the thin bladed grasses with few blades per plant (e.g., Spartina and Sporobolis) are counted less by the point frame method, while broad leafed herbs are counted more frequently (e.g., Cassia and Croton). Thus the quadrat method more clearly distinguishes the differences in plant community compositions in the two areas; but the decrease in diversity from NOTRAF to VEHTRAF is about equally well shown by the two methods.

Density ratios appear even more reliable with the VEHTRAF/NOTRAF ratio of plant or foliar densities determined by the quadrat method equal to 0.50 and by the point frame method equal to 0.54 for the vegetated part of the beach. If the density parameters are calculated for the entire beach, the quadrat method shows somewhat

Table 1. Plant Ranks at NOTRAF and VEHTRAF. Eight most abundant species determined by quadrat and point frame methods.

	NOTRAF		VEHTRAF	
rank	quadrat method	point frame method	quadrat method	point frame method
1	Spartina patens	Uniola paniculata	Ipomoea stolonifera	I. stolonifera
2	I. stolonifera	Oenothera drummundii	Croton punctatus	Croton punctatus
3	Oenothera drummundii	I. stolonifera	Cassia fasiculata	Cassia fasiculata
4	Sporobolis virginicus	Spartina patens	Spartina patens	Uniola paniculata
5	Uniola paniculata	Cassia fasiculata	Uniola paniculata	I. pes-caprae
6	Erigeron myrionactis	Tidestroemia lanuginosa	I. pes-caprae	Spartina patens
7	Tidestroemia lanuginosa	Croton punctatus	Tidestroemia lanuginosa	Tidestroemia lanuginosa
8	Euphorbia ammancides	Erigeron myrionactis	Oenothera drummundii	Oenothera drummundii
	83.9%	87.7%	98.8%	99.4%

% percent of all plants accounted for by these eight species.

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greater distinction of the two areas (quadrat VEH/NO plant density ratio = 0.42; point frame VEH/NO foliar density ratio = 0.62). However, the fact that the vegetative density in NOTRAF is about twice that in VETRAF is about equally shown by both methods.

In conclusion, the two methods contrast most in NOTRAF where diversity and density are greatest but give very nearly the same results in the sparser, less diverse flora of VEHTRAF.

RESULTS

Vegetative Differences

The data discussed in the previous section illustrate both greater diversity and greater density of plants in NOTRAF than in VEHTRAF. The chief differences in community composition are the greater abundances of the grasses *Spartina patens*, *Sporobolis virginicus*, and, perhaps, *Uniola paniculata* in NOTRAF and the absence of about a dozen of the lesser abundant species at VEHTRAF (e.g., *Paspalum monostachyum* and *Eragrostis oxlepis*). The percent compositions for each species and other vegetative items are given in Appendix A along with the several density parameters calculated for each survey method. A complete ranking of species by abundance is given in Table 2. The percent abundance of each species is the average value for all 12 transects in each area.

The range of values from transect to transect is large. On the average the value for any single item or parameter may range from zero to twice the mean value. Thus the importance of increasing the number of transects from one to twelve is demonstrated. Furthermore, comparisons with vegetative characteristics of PEDTRAF and

Table 2A. Plant Abundances of NOTRAF and VEHTRAF.

Plant	NOTRAF % and (rank)		VEHTRAF % and (rank)	
	Q	PF	Q	PF
Spartina	28.5(1)	13.1(4)	14.1(4)	4.2(6)
I. Stolonifera	19.0(2)	13.4(3)	34.1(1)	28.5(1)
Oenothera	9.3(3)	15.1(2)	2.7(8)	1.5(8)
Sporobolis	6.3(4)	2.3(10)	--	--
Uniola	6.2(5)	24.5(1)	6.9(5)	15.8(4)
Erigeron	5.3(6)	3.5(8)	--	--
Tidestroemia	5.2(7)	4.5(6)	4.8(7)	2.8(7)
Euphorbia	4.1(8)	3.0(9)	.8(9)	.5(10)
Cassia	3.6(9)	9.2(5)	14.7(3)	16.5(3)
Sesuvium	3.2(10)	1.8(12)	.1(11)	--
Paspalum	2.9(11)	2.1(11)	--	--
Croton	1.9(12)	4.4(7)	17.9(2)	22.3(2)
I. pes-caprae	1.1(13)	1.2(13)	5.6(6)	7.8(5)
Eragrostis	1.0(14)	.5(14)	--	--
Leptoma	.5(15)	--	--	--
Panicum	.3(16)	--	.2(10)	1.0(9)
Other forbes	(8)1.2	(5)1.4	--	--
Other grasses	(3) .4			

Q - quadrat method; PF - point frame method.

Table 2B. Plant Abundances at PEDTRAF and SHELL.

Plant	PEDTRAF % and (rank) Q	PEDTRAF % and (rank) PF	SHELL % and (rank) Q	SHELL % and (rank) PF
Cassia	28 (1)	38 (1)	33 (1)	24 (2)
Croton	21 (2)	18 (2)	6 (5)	12 (4)
Tidestroemia	5.4 (7)	11 (3)	--	--
Paspalum Mono.	10 (3)	7 (4)	--	--
Uniola	6.5 (5)	5.7 (5)	27 (2)	16 (3)
Amaranthus	4.5 (9)	5.7 (6)	--	--
I. stolonifera	8 (4)	4.6 (7)	7 (4)	--
Euphorbia	5.2 (8)	3.4 (8)	--	--
I. pes-caprae	1 (11)	2.3 (9)	.8 (6)	4 (5)
Sesuvium	5.5 (6)	2.3 (9)	--	--
Oenothera	4 (10)	.6 (10)	--	--
Heterotheca	--	--	26 (3)	44 (1)
Schizathyrium	.2 (13)	--	--	--
Sporobolus	.7 (12)	--	--	--

Q - quadrat method; PF - point frame method.

SHELL where only single transects were maintained should be considered only semiquantitative.

In addition to the vegetative diversities and densities, litter values were higher in NOTRAF than in VEHTRAF. Aerial litter is more than twice as abundant (36% and 16% respectively) and ground litter is one and one-half times as abundant (6.5% and 4.2% respectively).

The extent of vegetation (beach width from dune base to end of vegetation) during the first year of study was notably less at VEHTRAF (110 ft) than at NOTRAF (160 ft). However, the data shows that the average extents were nearly the same the second year (196 and 209 ft respectively). This resulted from the addition of a very sparse stand of predominantly *Tidestroemia lanuginosa* seaward of a back beach roadway.

Plant abundances at PEDTRAF and SHELL, although based on only a single transect at each site, showed that PEDTRAF was most like NOTRAF with very high plant diversity and density. However, the shrubs *Cassia* and *Croton* predominated over grasses like the community composition at VEHTRAF. SHELL, on the other hand, was even more sparsely and monotonously vegetated than VEHTRAF (Table 2B and Fig. 2).

Volume Changes

Volume changes were compared on the basis of the original profiles established in 1974 (Table 3 and Figure 3). Volumes determined from the 12 profiles in each of the two intensive study areas indicate that the original profiles were somewhat lower than the mean volumes for the areas. Whether trends of change through time are different for mean and single profile values will be determined by continued monitoring of the sites.

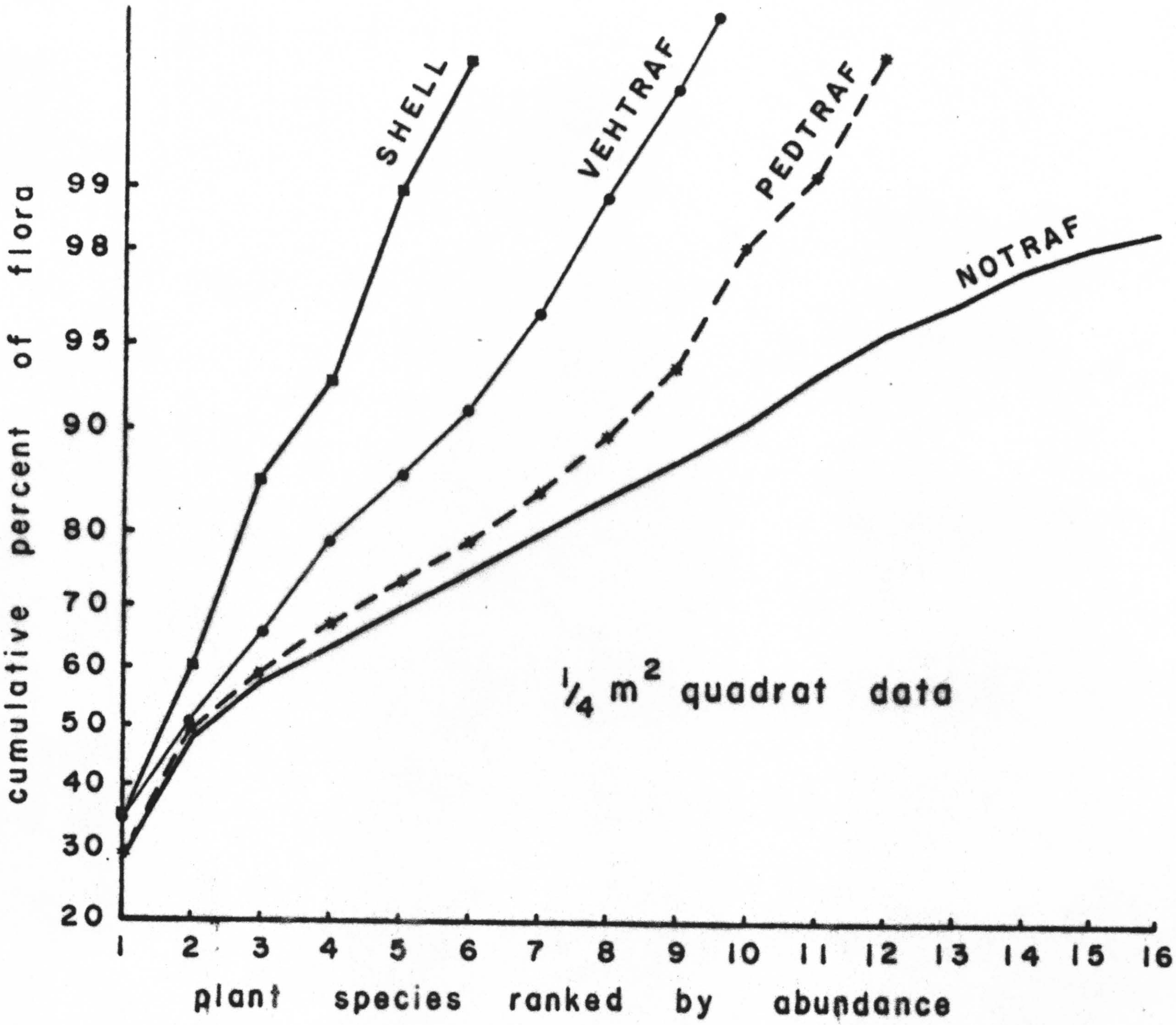

Figure 2. Plant Diversities of Study Sites

Table 3. Profile Changes at Original Profile Sites.

Avg. El./Transect to O'MSL

	FEET						Cubic feet per foot of beach	
	Ave. Beach El.	Ave. Veg. El.	Ave. Bare Beach El.	Veg. Distance	Transect Distance	Veg. Vol.	Bare Vol.	Totl. Vol.
NOTRAF								
4/17/74	4.34	6.21	2.91	160	350	994	524	1518
1/28/75	3.79	5.36	2.03	180	340	965	325	1290
10/75	4.72	6.39	2.63	200	360	1278	421	1699
VEHTRAF								
4/17/74	5.00	9.06	3.35	110	380	997	904	1901
1/28/75	5.04	9.69	3.33	110	410	1066	999	2065
10/75	5.18	7.64	2.26	190	350	1452	362	1814
SHELL								
4/17/74	4.74	7.17	3.86	90	340	646	965	1611
1/28/75	4.86	7.27	3.99	90	340	654	997.5	1651.5
10/21/75	4.91	7.39	4.02	90	340	665	1005	1670
PEDTRAF								
4/17/74	5.05	7.21	3.22	170	370	1226	643	1869
1/28/75	5.18	8.07	3.22	170	420	1372	805	2177
10/09/75		7.04		220		1549		

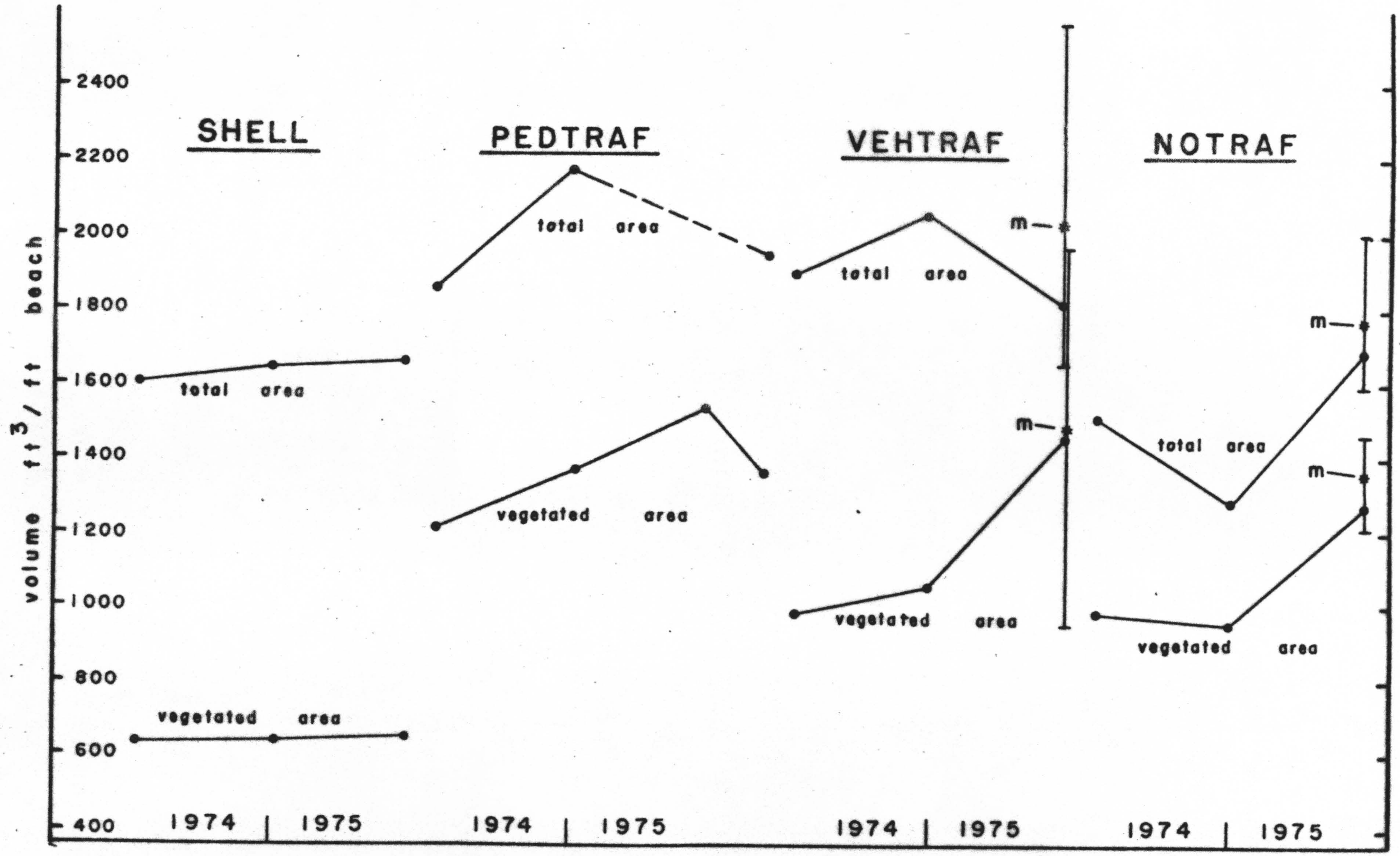

Figure 3. Beach Volume Changes. Beach volumes in cubic feet per linear foot of beach. Datum is mean sea level. Graphs are for original profile lines only. Means (m-*) and ranges (——) of 12 profiles in NOTRAF and VEHTRAF are plotted for October 1975.

SHELL underwent essentially no volume change in both the vegetated and unvegetated portions of the beach. The vegetated portions of all other beaches grew at rates from 20 to 43 cubic feet per month, which generally continues and accelerates the growths recorded in 1974. The VEHTRAF growth rate is highest, but this is largely an artifact of the addition of a considerable width of beach colonized by *Tidestroemia* since 1974. In contrast, the entire beach at VEHTRAF showed the greatest loss of volume for the entire beach (28 cubic feet per month). The PEDTRAF profile was not extended far enough to include data for the entire beach at that site. However, resurvey at a later date showed an overall loss of volume at this site too. The total volume of beach at NOTRAF has increased to equal the stabilized beach at SHELL. The total volumes of both VEHTRAF and PEDTRAF are greater, but if the present rates of change are continued, the beach at NOTRAF will become larger.

The variability of sand volumes (like that of plant compositions) is greater in VEHTRAF than in NOTRAF. Standard deviations of values for VEHTRAF are usually over twice those for NOTRAF.

Volumes of sand above the hypothetical hurricane beach profile (page 4) did not change at SHELL, but increased markedly at all other sites (Table 3). However, the hurricane beach volumes (volume of sand above the hurricane beach profile) were determined for only the distance from the base of the dunes to the berm crest (Behrens *et al.*, 1975). This is mostly vegetated backshore and thus follows the trends of volumes calculated to the msl datum for the vegetated portions of the beaches.

DISCUSSION

The results of this study support the qualitative information of the 1974 study that the less trafficked beaches contain more vegetation than equivalent, heavily used beaches. However, analysis of all four sites might be best done by first comparing the two most contrasting sites, SHELL and NOTRAF.

At SHELL plant density and diversity are lowest of the four sites, probably because the high shell content of the beach leads to lower soil moisture, higher salinity, and higher soil temperatures than at the other sites. The exceptionally high berm there may also decrease the supply of nutrients that normally accompany onshore wind transported sediment. The extreme stability of beach sediment volumes there (4% change in 1½ years) indicates that sediment supply is essentially nil. An additional indication of nutrient supply through recycling is the litter available at each site. At SHELL 50% of the foliage is aerial litter, the highest value for any site. This suggests that plant vigor is relatively low in this area and that aerial abrasion is low. Abrasion from actual contact with traffic must be low because traffic is light in this area. Furthermore, abrasion by air-borne sand must also be very low, because of the minimal sedimentation rate. The lack of sediment deposition hinders the aerial material from accumulating in the soil; and this is reflected in the fact that SHELL has the minimum ground litter (1%) for the four sites. The sparse plant community adapted to this harsh environment is dominated by the composite Heterotheca, and the sub-shrubs Cassia and Croton supplemented by the vine Ipomoea and the grass Uniola; and these five genera constitute 99% of the flora.

At NOTRAF, on the other hand, three of the five most abundant species are grasses, and the first five genera constitute only 70% of the flora. The plant densities (quadrat method) are three times those at SHELL. The chief reason for the greatest diversity and high density at NOTRAF is probably the protection from onshore wind effects afforded a larger portion of the beach by the seawardmost plants which grow unhampered by traffic to within at least 50 feet of the berm. The protecting position of the small dunes created by this vegetation is shown in the NOTRAF profiles in Appendix C. McAtee (1975) showed that wind intensities one meter above the surface at NOTRAF, PEDTRAF, and VEHTRAF are the same, but closer to the ground velocities are significantly less at NOTRAF. Oosting (1954) claimed that salt spray intensity most limits the strand vegetation, while Van Der Valk (1974) showed that "shifting sand...is responsible for the absence of forbes on the front of the foredune" in Cape Hatteras National Seashore. Both of these detrimental factors are diminished by the lower wind speeds which we attribute to the wind breaking effect of the embryonic dunes attached to the seawardmost vegetation at NOTRAF.

The sediment accumulation at NOTRAF has proceeded as predicted, that is, there has been steady growth of the beach in the absence of storm surges. The most distinctive feature of this growth is that it applies to the entire width of the beach at least to msl. In fact the growth for the entire beach is somewhat greater than for the vegetated portion (Table 4). This contrasts sharply with VEHTRAF where the vegetated portion of the beach grew faster but where the beach as a whole lost sediment.

The beach at PEDTRAF appears to have behaved most like that at VEHTRAF, i.e., the vegetated portion gained while the whole beach lost sediment (Table 4).

Table 4. Rates of Sedimentation, January - October 1975.

Site	Traffic Conditions	Whole Beach	Vegetated Beach
VEHTRAF	- greatest combined traffic	-28 ft^3/mo.	+43 ft^3/mo.
PEDTRAF	- heavy foot traffic, no vehicular	-17* "	+20 "
SHELL	- soft shell limits traffic to low levels	+ 2 "	+ 1 "
NOTRAF	- almost no traffic	+45 "	+35 "

*October values interpolated from a later survey (February 1976)

The data in Table 4 suggest that growth of the vegetated portions of the beaches is due to a combination of factors, but the loss from the unvegetated portions (reflected in the whole beach vs. the vegetated beach data) correlates directly with the degree of usage. Although correlation does not prove causation, several mechanisms exist for traffic to effect these losses: a) the movement of wheels and feet on the beach lifts more sand into the wind than the wind could pick up by shear stress alone and lifts it higher than the wind could by itself. At greater heights the wind has greater speed (McAtee, 1975, Fig. 19) and thus can carry more sand farther from the unvegetated part of the beach to the vegetated zones; b) traffic destroys sand trapping vegetation directly by crushing and increasing sand abrasion and indirectly by increasing wind and accompanying salt spray and sand transport as vegetation is destroyed; and c) as traffic destroys the small impediments that the embryonic dunes afford it, the traffic zone widens and exposes more beach to effects (a) and (b).

Although both onshore and offshore winds occur in the study areas, onshore sand transport is probably predominant and considerably enhanced by traffic. This is because the onshore wind mode is not only larger than the offshore mode but also is prevalent during the summer when traffic is many times heavier than during winter when northers produce the offshore mode and keep tourists away. Thus the sand lost from the unvegetated parts of the beaches is gained in the landward, vegetated parts. However, the net losses suggest that some of the sand moves beyond the beach into, and perhaps through, the high dune ridge. This is supported by the loss of plant vigor within the dunes and even farther landward of sites where beach traffic is heaviest (McAtee, 1975).

At SHELL the almost zero sedimentation rate (1 cubic foot per month) may result in a deficiency of nutrients usually supplied with the sediment and accompanying salt spray (Clayton, 1972). At PEDTRAF, with the second lowest vegetated beach sedimentation rate, the increase to 20 cubic feet per month of sedimentation in the vegetated zone correlates with the highest plant density of the four study sites. However, evidence of the detrimental effects of increased sand movement and salt spray is clear in the change of the composition of the plant community from the maximum diversity as at NOTRAF toward the more restricted and shrubbier flora at VEHTRAF and SHELL. As sedimentation rates for the vegetated beach zones increase to the maximum value at VEHTRAF the detrimental effects overcome any benefit from increase of nutrient supply; and the vegetated beach growth is at the expense of both the density and diversity of the plant community as well as at the expense of the seaward portion of the beach.

The study period has been within a period of normal annual rainfall (Fig. 4). Thus the beach conditions that have been monitored probably represent nearly average conditions. Considering the extreme divergences from normal which are characteristic of the climate in this region (Fig. 4), considerable natural variations in beach vegetation and sedimentary behavior may occur even in the absence of tropical storm surge. During drought periods even NOTRAF type beaches may have net losses of materials through deflation of a vegetatively depleted beach. On the other hand during very wet periods even heavily trafficked beaches may maintain satisfactory vegetative cover to prevent significant loss of sediment. The variations in annual rainfall shown in Figure 4 suggest that a full spectrum of meteorological conditions is usually observable in a period of ten years.

Other environmental variables which may affect beach behavior have not been sufficiently monitored to determine what part of their ranges the study period represents. These include annual resultant wind, extra-tropical storm tides, and influx of Sargassum weed.

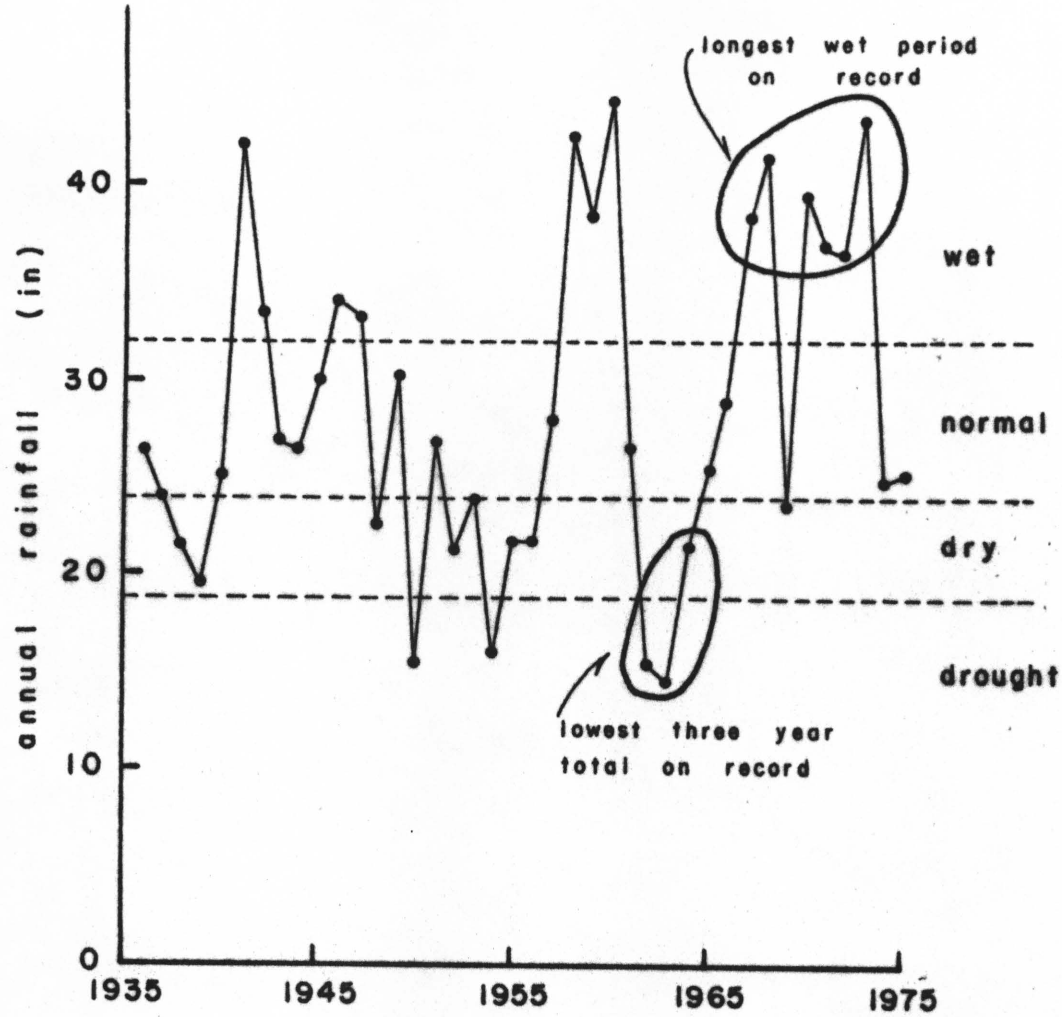

Figure 4. Annual rainfall for Corpus Christi, Texas. Drought, dry, normal, and wet designations are after Behrens (1966).

CONCLUSIONS

1. Of the four sites studied, SHELL has the most restricted plant community because of the naturally harsh environment there. The plant communities of the other sites become more like that at SHELL as beach traffic increases (Fig. 2). This most likely results from increases in harshness of the microenvironments caused by the traffic as well as the damage done to the vegetation by direct contact with vehicles and people.

2. Greater sediment mobility caused by heavier traffic can lead to greater accumulation of sand in the vegetated portion of the beach; but this is at the expense of the outer beach and has lead to an overall reduction in beach volume at PEDTRAF and VEHTRAF.

3. The undisturbed beach, NOTRAF, continues to grow in the absence of a tropical storm surge. The hypothesis that this will lead to greater resistance to storm surge erosion remains to be tested.

FURTHER STUDIES

In order to accomplish the primary goals of the studies begun in 1974, monitoring the established transects should continue for several years. Vegetative surveys done twice per year and beach profiles surveyed quarterly would accomplish the necessary annual monitoring. Special meteorological or environmental events, especially storm surges, should be followed by surveys as soon as possible. These surveys would provide the basic data for the original questions - how do storm surges affect beaches with different vegetative cover resulting from different degrees and types of traffic - and - if a storm effect is observed, what is its importance relative to the normal range of variations in beach conditions from wet periods with over 32 inches to drought periods with less than 19 inches of annual rainfall?

Several additional questions arise from the studies conducted so far.

1) Do the more or less instantaneous measurements of sand volumes represent short term (daily, fortnightly, monthly) conditions or stable, long-term (annual) trends? Sedimentological conditions in other dynamic environments such as tidal inlets often vary much more through a monthly tidal cycle than from month to month or year to year. The specific beach responses to typical diurnal and semidiurnal tidal cycles should be investigated by at least weekly surveys of selected profiles for representative portions of the seasonal cycles.

2) Do losses of beach material from the unvegetated seaward parts of beaches reflect additional, potentially more serious losses across the submerged surf zone? The answer to this question would require extending the beach profile elevation surveys 1,200 to 2,400 feet from shore. This can be done only at considerably increased effort and expense using a surf sled technique.

3) Does the change to the plant community produced by traffic reach an equilibrium or is destruction progressive? The answer for beach vegetation would be evident from the continued monitoring required to answer the basic questions about storm effects and natural variations. An important extention of this question, though,

is the effect noted by McAtee (1975) of traffic on the more landward vegetation. Extention of at least some (probably one-half) of the profiles across the high dune ridge and onto the barrier flats and continuation of the study for several years should give a good indication of the answer to this question.

4) Is the stability of the single transect located on a shell beach (SHELL) representative of this environment? In view of the different management plans that would be appropriate for stable vs. eroding beaches, the representativeness of the SHELL profile should be determined by surveying at least five additional transects in that area.

5) What quantitative levels of traffic produced the observed effects on beach conditions? The answer to this question requires some monitoring of traffic levels. Whereas access to the VEHTRAF and NOTRAF sites are via single roads, vehicle counters on these roads would be roughly equivalent to the amount of traffic on the beach. A counter on the NOTRAF road should not be necessary, because it has so little traffic and is accessible only through the Ranger Station, so personnel of that station should be able to monitor traffic to NOTRAF. Periodic counts of vehicles or people along the beach would enable a more accurate estimation of the level of traffic at any particular distance from the access road. These data could be collected with a minimum of effort with a series of at least semi-weekly photographs taken on routine beach patrols. The photos could also be very useful in analysing beach usage by activity.

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APPENDIX A

Transect vegetation itemization and density parameters by transect

1) plants grouped as types with most abundant in each group listed first

2) family

NOTRAF 28/10/75 ¼ M^2 QUADRAT

	Species	Family
Grasses:	Spartina patens	Graminae
	Sporobolus virginicus	Graminae
	Uniola paniculata	Graminae
	Paspalum monostachyum	Graminae
	Eragrostis oxylepis	Graminae
	Leptoloma cognatum	Graminae
	Panicum amarum	Graminae
	*Fimbristylis castanea	Graminae
	Centrus incertus	Graminae
	Chloris petraea	Graminae
Forbs:	Ipomoea stolonifera	Convolvulaceae
	Oenothera drummondii	Onagraceae
	Erigeron myrionactis	Compositae
	Tidestroemia lanuginosa	Amaranthaceae
	Euphorbia ammanoides	Euphorbiaceae
	Cassia fasiculata	Leguminosae
	Sesuvium portulacastrum	Aizoceae
	Croton punctatus	Euphorbiaceae
	Ipomoea pes-caprae	Convolvulaceae
	**Amaranthus greggii	Amaranthaceae
	Heterotheca subaxillaris	Compositae
	Physalis viscosa	Solanaceae
	Phyla nodiflora	Verbenaceae
	Ambrosia psilostachya	Compositae
	Cyperus esculentus	Cyperaceae
	Cyperus spp.	Cyperaceae

*less than .3%
**less than 1.1%

NOTRAF 10-28-75 ¼ M^2 QUADRAT

Transect	Species	Composition # Ind.	Composition % Foliar	Density 210' Foliar	Density 410' Foliar to 0 MSL
2.4	Uniola paniculata	17	.015	.085	.041
	Spartina patens	689	.61	3.45	1.68
	Sporobolus virginicus	104	.09	.52	.25
	Paspalum monostachyum				
	Croton punctatus	33	.03	.17	.080
	Erigeron myrionactis	97	.085	.49	.236
	Tidestroemia lanuginosa	131	.115	.66	.319
	Oenothera drummondii	17	.015	.085	.041
	I. stolonifera	37	.03	.185	.090
	I. pes-caprae	3	.003	.015	.007
	Heterotheca subaxillaris	2	.002	.01	.005
	Cyperus esculentus	1	.001	.005	.002
	Total =	1131		= 5.675	= 2.751
				200'	380'
2.0	Uniola paniculata	21	.05	.105	.055
	Spartina patens	253	.64	1.265	.666
	Sporobolus virginicus	7	.02	.035	.018
	Paspalum monostachyum	10	.025	.05	.026
	Erigeron myrionactis	17	.04	.085	.045
	Tidestroemia lanuginosa	15	.04	.075	.039
	Oenothera drummondii	36	.09	.18	.095
	I. stolonifera	29	.07	.145	.076
	I. pes-caprae	8	.02	.04	.021
	Amaranthus greggii	2	.005	.01	.005
	Total =	398		= 1.990	= 1.046
				220'	415'
1.6	Uniola paniculata	35	.11	.16	.08
	Spartina patens	40	.12	.18	.10
	Sporobolus virginicus	21	.06	.095	.05
	Tidestroemia lanuginosa	36	.11	.16	.09
	Oenothera drummondii	42	.13	.19	.10
	I. stolonifera	58	.18	.26	.14
	Cassia fasiculata	47	.14	.21	.11
	Euphorbia ammanoides	49	.15	.22	.12
	Total =	328		= 1.475	= .79

NOTRAF 10-30-75 ¼ M^2 QUADRAT

Transect	Species	Composition # Ind.	Composition % Foliar	Density 240' Foliar	Density 480' Foliar to 0 MSL
1.2	Uniola paniculata	1	.001	.004	.002
	Spartina patens	209	.32	.87	.43
	Sporobolus virginicus	69	.11	.29	.14
	Paspalum monostachyum	8	.01	.03	.02
	Eragrostis oxylepis	13	.02	.05	.03
	Leptoloma cognatum	1	.001	.004	.002
	Chloris petraea	1	.001	.004	.002
	Fimbristylis castanea	12	.02	.05	.025
	Erigeron myrionactis	48	.07	.20	.10
	Tidestroemia lanuginosa	22	.03	.09	.045
	Oenothera drummondii	87	.135	.36	.18
	I. pes-caprae	7	.01	.03	.01
	I. stolonifera	43	.07	.18	.09
	Cassia fasiculata	7	.01	.03	.01
	Euphorbia ammanoides	52	.08	.22	.11
	Phyla nodiflora	2	.003	.008	.004
	Sesuvium portulacastrum	59	.09	.25	.12
	Cyperus esculentus	3	.005	.01	.006
	Total =	644		= 2.680	= 1.326
				200'	400'
0.8	Uniola paniculata	38	.11	.19	.095
	Spartina patens	67	.20	.33	.167
	Croton punctatus	9	.03	.045	.022
	I. pes-caprae	1	.003	.005	.002
	I. stolonifera	117	.35	.585	.292
	Euphorbia ammanoides	103	.31	.515	.257
	Phyla nodiflora	1	.003	.005	.002
	Total =	336		= 1.670	= .837
				200'	480'
0.4	Uniola paniculata	1	.003	.005	.002
	Spartina patens	48	.16	.24	.1
	Sporobolus virginicus	6	.02	.03	.012
	Panicum amarum	3	.01	.015	.006

NOTRAF 10-30-75 (cont.) ¼ M^2 QUADRAT

Transect	Species	Composition # Ind.	Composition % Foliar	Density 200' Foliar	Density 480' Foliar to 0 MSL
0.4	Croton punctatus	12	.04	.06	.025
	Oenothera drummondii	98	.34	.49	.20
	I. pes-caprae	15	.05	.075	.03
	I. stòlonifera	55	.19	.275	.114
	Sesuvium portulacastrum	53	.18	.09	.110
	Total =	291		= 1.28	= .599

NOTRAF 10-7-75 ¼ M^2 QUADRAT

Transect	Species	Composition # Ind.	Composition % Foliar	Density 190' Foliar	Density 345' Foliar to 0 MSL
800 S	Uniola paniculata	59	.21	.31	.17
	Sporobolus virginicus	28	.10	.147	.08
	Croton punctatus	13	.05	.068	.04
	Tidestroemia lanuginosa	9	.033	.047	.026
	Oenothera drummondii	68	.250	.357	.197
	I. pes-caprae	6	.022	.031	.017
	I. stolonifera	79	.291	.415	.22
	Sesuvium myrionactis	9	.033	.047	.026
	Total =	271		= 1.422	= 0.776
				190'	330'
620 S	Uniola paniculata	43	.11	.122	.130
	Sporobolus virginicus	9	.022	.047	.027
	Paspalum monostachyum	49	.123	.257	.148
	Centrus incertus	5	.012	.026	.015
	Panicum amarum	12	.03	.063	.036
	Tidestroemia lanuginosa	6	.015	.031	.018
	Oenothera drummondii	47	.118	.247	.14
	I. stolonifera	85	.214	.447	.257
	Erigeron myrionactis	9	.022	.047	.027
	Cassia fasiculata	113	.285	.594	.342
	Ambrosia psilostachya	9	.022	.047	.027
	Amaranthus greggii	8	.020	.042	.024
	Cyperus esculentus	1	.002	.005	.003
	Total =	396		= 2.778	= 1.194

NOTRAF 10-6-75 ¼ M^2 QUADRAT

Transect	Species	Composition # Ind.	Composition % Foliar	Density 210' Foliar	Density 330' Foliar to 0 MSL
580 S	Uniola paniculata	1	.006	.005	.003
	Spartina patens	4	.025	.019	.012
	Leptomoma cognatum	19	.120	.090	.057
	Tidestroemia lanuginosa	15	.095	.071	.045
	Oenothera drummondii	17	.107	.081	.051
	I. stolonifera	95	.601	.452	.288
	Cassia fasiculata	1	.006	.008	.003
	Sesuvium myrionactis	6	.038	.028	.018
	Total = 158			= .754	= .933
				230'	360'
400 S	Uniola paniculata	1	.002	.004	.003
	Sporobolus virginicus	23	.057	.1	.064
	Paspalum monostachyum	26	.065	.113	.072
	Eragrostis oxylepis	5	.012	.022	.014
				= .239	= .153
	Oenothera drummondii	39	.097	.169	.11
	I. stolonifera	239	.597	1.04	.664
	I. pes-caprae	13	.033	.056	.036
	Erigeron myrionactis	32	.08	.139	.089
	Sesuvium myrionactis	22	.055	.096	.061
	Total = 400			= 1.5	= .960
				220'	360'
200S	Uniola paniculata	45	.20	.20	.125
	Sporobolus virginicus	40	.18	.18	.111
	Eragrostis oxylepis	18	.08	.08	.05
	Croton punctatus	26	.12	.12	.072
	Tidestroemia lanuginosa	22	.10	.10	.061
	Oenothera drummondii	3	.01	.01	.008
	I. stolonifera	63	.28	.28	.175
	Sesuvium myrionactis	5	.02	.02	.138
	Total = 222			= .9945	= .740

NOTRAF Preliminary Date 10-3-75 ¼ M^2 QUADRAT

Transect	Species	Composition # Ind.	Composition % Foliar	Density 196' Foliar	Density 360' Foliar to 0 MSL
0	Uniola paniculata	42	.12	.21	.116
	Spartina patens	98	.28	.5	.272
	Sporobolus virginicus	2	.005	.01	.006
	Paspalum monostachyum	48	.14	.24	.133
	Eragrostis oxylepis	15	.04	.08	.041
	Leptomoma cognatum	6	.02	.03	.017
	Fimbristylis castanea	6	.02	.03	.017
	Croton punctatus	2	.005	.01	.006
	Erigeron myrionactis	58	.17	.30	.161
	Tidestroemia lanuginosa	1	.003	.005	.003
	Oenothera drummondii	7	.02	.04	.020
	I. pes-caprae	2	.005	.01	.006
	I. stolonifera	36	.10	.18	.10
	Cassia fasiculata	8	.02	.04	.02
	Physalis viscosa	1	.003	.005	.003
	Sesuvium myrionactis	4	.01	.02	.011
	Amaranthus greggii	2	.005	.01	.006
	Cyperus esculentus	1	.003	.005	.003
	Cyperus unk. #3	8	.02	.04	.022
	Total = 347			= 1.765	= .963
				m = 2.019	m = 1.089
				Tot. 24.2225	13.068 Tot.

VEHTRAF 28/10/75 ¼ M^2 QUADRAT

	Species	Family
Grasses:	Spartina patens	Graminae
	Uniola paniculata	Graminae
	*Panicum amarum	Graminae
Forbs:	Ipomoea stolonifera	Convolvulaceae
	Croton punctatus	Euphorbiaceae
	Cassia fasiculata	Leguminosae
	Ipomoea pes-caprae	Convolvulaceae
	Tidestroemia lanuginosa	Amaranthaceae
	Oenothera drummondii	Onagraceae
	Euphorbia ammanoides	Euphorbiaceae
	**Sesuvium portulacastrum	Aizoceae

* 0.2%
** 0.1%

VEHTRAF 10-28-75 ¼ m^2 QUADRAT

Transect	Species	Composition #Ind.	Composition % Foliar	Density 150' Foliar	Density 360' Foliar to 0 MSL
2.3	Uniola paniculata	7	.08	.046	.019
	Spartina patens	4	.05	.266	.011
	Croton punctatus	11	.13	.073	.03
	I. stolonifera	47	.55	.31	.13
	Sesuvium portulacastrum	3	.03	.02	.008
	Euphorbia ammanoides	8	.095	.053	.02
	Tidestroemia lanuginosa	4	.05	.026	.011
	Total	= 84		= .794	= .229
				230'	360'
2.0	Croton punctatus	45	.21	.195	.125
	I. pes-caprae	1	.005	.004	.003
	I. stolonifera	107	.50	.465	.30
	Oenothera drummondii	55	.26	.24	.15
	Tidestroemia lanuginosa	4	.02	.02	.01
	Total	= 212		= .92	= .59
				200'	390'
1.7	Uniola paniculata	1	.004	.05	.002
	Spartina patens	91	.39	.455	.23
	Croton punctatus	84	.36	.42	.21
	I. stolonifera	37	.16	.185	.09
	I. pes-caprae	2	.01	.01	.005
	Tidestroemia lanuginosa	17	.07	.085	.04
	Total	= 232		= 1.120	= .577

VEHTRAF 10-28-75 (cont.) ¼ m^2 QUADRAT

Transect	Species	Composition #Ind.	% Foliar	Density 240' Foliar	420' Foliar to 0 MSL
1.4	Uniola paniculata	18	.05	.075	.04
	Croton punctatus	90	.23	.375	.21
	I. stolonifera	34	.09	.14	.08
	I. pes-caprae	10	.02	.04	.02
	Cassia fasiculata	237	.61		
	Total	= 389		= 1.62	= .91

VEHTRAF

¼ m^2 QUADRAT

Transect	Species	Composition #Ind.	Composition % Foliar	Density 110' Foliar	Density 410' Foliar to 0 MSL
1.0 (10-23-75)	Croton punctatus	50	.33	.45	.12
	I. stolonifera	103	.67	.94	.25
	Total	= 153		= 1.39	= .37
				170'	360'
0.6 (10-23-75)	Uniola paniculata	49	.34	.28	.136
	I. stolonifera	55	.38	.32	.152
	I. pes-caprae	35	.24	.21	.097
	Cassia fasiculata	4	.03	.02	.01
	Total	= 143		= .83	= .395
				240'	385'
1000N (10-8-75)	Spartina patens	17	.215	.071	.044
	I. stolonifera	33	.42	.14	.085
	I. pes-caprae	24	.30	.10	.062
	Tidestroemia lanuginosa	5	.06	.021	.013
	Total	= 79		= .332	= .204
				220'	420'
800N (10-8-75)	I. stolonifera	41	.72	.19	.09
	Tidestroemia lanuginosa	16	.28	.07	.038
	Total	= 57		= .33	= .164

VEHTRAF

¼ m^2 QUADRAT

		Composition		Density	
Transect	Species	#Ind.	% Foliar	235' Foliar	430' Foliar to 0 MSL
600 N (10-8-75)	Uniola paniculata	14	.065	.06	.03
	Croton punctatus	112	.525	.48	.26
	I. stolonifera	59	.28	.25	.13
	Cassia fasiculata	28	.13	.12	.065
	Total	= 213		= .91	= .485
				210'	430'
400N (10-8-75)	Spartina patens	101	.40	.48	.23
	Panicum amarum	4	.02	.019	.009
	Croton punctatus	7	.03	.03	.016
	I. stolonifera	99	.39	.47	.23
	I. pes-caprae	1	.004	.005	.002
	Tidestroemia lanuginosa	41	.16	.195	.09
	Total	= 253		= 1.20	= .57
				185'	370'
200N (10-9-75)	Uniola paniculata	13	.05	.07	.035
	Spartina patens	70	.28	.38	.189
	Croton punctatus	9	.03	.05	.02
	I. stolonifera	145	.58	.78	.039
	Cassia fasiculata	5	.02	.03	.013
	Tidestroemia lanuginosa	9	.035	.05	.02
	Total	= 251		= 1.36	= .316

VEHTRAF

¼ m^2 QUADRAT

Transect	Species	Composition #Ind.	Composition % Foliar	Density 190' Foliar	Density 350' Foliar to 0 MSL
ØN (10-9-75)	Uniola paniculata	36	.17	.19	.10
	Croton punctatus	2	.009	.01	.006
	I. stolonifera	108	.502	.57	.31
	I. pes-caprae	40	.19	.21	.11
	Cassia fasiculata	21	.097	.11	.06
	Euphorbia ammanoides	8	.04	.04	.02
	Total	= 215		= 1.13	= .606
				m = 1.015	m = .461
				Total 12.184	Total 5.54

SHELL | 21/10/75 | ¼ M^2 QUADRAT

	Species	Family
Grasses:	Uniola paniculata	Graminae
Forbs:	Cassia fasiculata	Leguminosae
	Heterotheca subaxillaris	Compositae
	Ipomoea stolonifera	Convolvulaceae
	Croton punctatus	Euphorbiaceae
	Ipomoea pes-caprae	Convolvulaceae

PEDTRAF | 9/10/75 | ¼ M^2 QUADRAT

	Species	Family
Grasses:	Paspalum monostachyum	Graminae
	Uniola paniculata	Graminae
	Sporobolus virginicus	Graminae
	Schizachyrium scoparius	Graminae
Forbs:	Cassia fasiculata	Leguminosae
	Croton punctatus	Euphorbiaceae
	Ipomoea stolonifera	Convolvulaceae
	Sesuvium portulacastrum	Aizoceae
	Tidestroemia lanuginosa	Amaranthaceae
	Euphorbia ammanoides	Euphorbiaceae
	Amaranthus greggii	Amaranthaceae
	Oenothera drummundii	Onagraceae
	Ipomoea pes-caprae	Convolvulaceae

SHELL

¼ m^2 QUADRAT

	Species	Composition #Ind.	Composition % Foliar	Density 203' Foliar	Density 340' Foliar to 0 MSL
10-21-75	Uniola paniculata	33	27	.163	.097
	Croton punctatus	7	6	.034	.021
	Cassia fasiculata	40	33	.197	.118
	Heterotheca subaxillaris	32	26	.153	.094
	I. pes-caprae	1	.8	.005	.003
	I. stolonifera	9	7	.044	.026
	Total	122		= .596	= .359

PEDTRAF

	Species	#Ind.	% Foliar	222'	
10-9-75	Uniola paniculata	39	6.5	.18	none
	Paspalum monostachyum	60	10	.27	none
	Schizachyrium scoparius	1	.2	.005	none
	Sporobolus virginicus	4	.7	.02	none
	Croton punctatus	124	21	.56	none
	Cassia fasiculata	169	28	.76	none
	Oenothera drummundii	24	4	.11	none
	I. pes-caprae	6	1	.03	none
	I. stolonifera	47	8	.21	none
	Euphorbia ammanoides	31	5.2	.14	none
	Amaranthus greggii	27	4.5	.12	none
	Tidestroemia lanuginosa	32	5.4	.14	none
	S. portulacastrum	33	5.5	.15	none
	Total	597		= 2.695	

NOTRAF 28/10/75 POINT FRAME

	Species	Family
Grasses:	Uniola paniculata	Graminae
	Spartina patens	Graminae
	Sporobolus virginicus	Graminae
	Paspalum monostachyum	Graminae
	Eragrostis oxylepis	Graminae
	*Leptoloma cognatum	Graminae
	Panicum amarum	Graminae
	Centrus incertus	Graminae
Forbs:	Oenothera drummundii	Onagraceae
	Ipomoea stolonifera	Convolvulaceae
	Cassia fasiculata	Leguminosae
	Tidestroemia lanuginosa	Amaranthaceae
	Croton punctatus	Euphorbiaceae
	Erigeron myrionactis	Compositae
	Sesuvium portulacastrum	Aizoceae
	Ipomoea pes-caprae	Convolvulaceae
	**Euphorbia ammanoides	Euphorbiaceae
	Ambrosia psilostachya	Compositae
	Amaranthus greggii	Amaranthaceae
	Cyperus sp.	Cyperaceae

* less than .5%
** less than 1.2%

NOTRAF 10-28-75 POINT FRAME

Transect	Species	# Ind.	Composition % Foliar	% Basal	% Ground	Density 210' Foliar	Basal	Ground	410' Foliar to 0 MSL
2.4	Uniola	2	.01	.08	.005	.01	.005	.005	.005
	Spartina	28	.21			.14			.068
	Sporobolus	3	.02			.015			.007
	Pasp. mono.	4	.03			.02			.010
	Tidestroemia	12	.09			.057			.029
	Croton	7	.05			.033			.017
	Oenothera	5	.04	.53	.02	.025	.035	.015	.012
	Erigeron	7	.05	.15	.005	.033	.01	.005	.017
	I. stolonifera	5	.04	.23	.02	.025	.015	.015	.012
	AL*	62	.46			.31			.151
	BG*	173			.90			.865	
	GL*	12			.06			.06	
						= .668			= .328
						200'			380'
2.0	Uniola	5	.05			.025			.013
	Spartina	27	.30	1.0	.006	.135	.025	.025	.071
	Oenothera	4	.04			.02			.010
	Erigeron	5	.05			.025			.013
	I. stolonifera	1	.01			.005			.003
	AL*	50	.54			.25			.132
	BG*	169			.97			.845	
	GL*	5			.03			.025	
						= .325			= .242

NOTRAF

10-28-75 (cont.)

POINT FRAME

Transect	Species	# Ind.	% Foliar	% Basal	% Ground	220' Foliar	Basal	Ground	415' Foliar to 0 MSL
		Composition				Density			
1.6	Uniola	25	.24			.11			.060
	Spartina	2	.02	.14	.005	.01	.004	.004	.005
	Sporobolus	1	.01	.14	.005	.004	.004	.004	.002
	Tidestroemia	2	.02	.28	.005	.01	.01	.004	.005
	Cassia	12	.12			.05			.029
	Euphorbia	4	.04			.02			.010
	Oenothera	6	.06	.14	.005	.03	.01	.01	.014
	I. stolonifera	7	.07	.28	.01	.03			.017
	AL*	43	.42			.195			.104
	BG*	187			.94			.85	
	GL*	7			.035			.03	
						= .459			= .468

*AL = aerial litter; BG = bare ground; GL = ground litter

NOTRAF 10-30-75 POINT FRAME

Transcect	Species	# Ind.	% Foliar	% Basal	% Ground	240' Foliar	Basal	Ground	480' Foliar to 0 MSL
		Composition				Density			
1.2	Uniola	3	.04			.0125			.006
	Spartina	12	.16	.11	.009	.05	.01	.01	.025
	Sporobolus	6	.08	.05	.004	.02	.004	.004	.012
	Eragrostis	2	.03			.01			.004
	Tidestroemia	8	.11			.03			.017
	Euphorbia	4	.07	.05	.004	.02	.004	.004	.008
	Oenothera	9	.12	.28	.01	.04	.02	.01	.019
	Erigeron	4	.05	.17	.009	.02	.01	.01	.008
	I. pes-caprae	1	.01			.004			.002
	I. stolonifera	2	.03	.33	.03	.01	.02	.02	.004
	Sesuvium	2	.03			.01			.004
	AL*	21	.28			.08			.044
	BG*	212			.93			.85	
	GL*	1			.004			.004	
						= .306			= .153
						200'			400'
0.8	Uniola	30	.30	.25	.005	.15	.01	.005	.075
	Spartina	4	.04			.02			.01
	Croton	3	.03			.015			.007
	Euphorbia	11	.11	.375	.011	.06	.015	.01	.027
	I. stolonifera	21	.21	.375	.011	.11	.015	.015	.052
	AL*	32	.32			.16			.080
	BG*	175			.938			.875	
	GL*	8			.042			.04	
						= .515			= .234

NOTRAF

10-30-75 (cont.)

POINT FRAME

		Composition				Density			
Transect	Species	# Ind.	% Foliar	% Basal	% Ground	200' Foliar	Basal	Ground	480' Foliar to 0 MSL
0.4	Uniola	3	.06			.015			.006
	Spartina	3	.06			.015			.006
	Croton	5	.10			.025			.010
	Euphorbia	1	.02			.005			.002
	Oenothera	16	.31	.428	.017	.08	.015	.015	.033
	I. pes-caprae	3	.06			.015			.006
	I. stolonifera	5	.10	.428	.017	.025	.015	.015	.010
	Sesuvium	3	.06	.143	.006	.015	.005	.005	.006
	AL*	12	.235			.06			.025
	BG*	163			.953			.815	
	GL*	1			.006			.015	
						= .255			= .104

*AL = aerial litter; BG - bare ground; GL = ground litter

NOTRAF 10-7-75 POINT FRAME

Transect	Species	Composition: # Ind.	Composition: % Foliar	Composition: % Basal	Composition: % Ground	Density: 200' Foliar	Density: Basal	Density: Ground	Density: 345' Foliar to 0 MSL
800 S	Uniola	30	.33	.6		0.15	.015	.015	.087
	Sporobolus	2	.02		.02	0.01			.006
	Oenothera	11	.12	.2	.01	0.055	.005	.005	.032
	I. stolonifera	3	.03	.2		0.015	.005	.005	.009
	I. pes-caprae	1	.01			0.005			.003
	Sesuvium	1	.01			0.005			.003
	AL*	43	.47			0.215			.125
	BG*	140			.85			.70	
	GL*	19			.11			.095	
						= .455			= .265
						190'			330'
620 S	Uniola	22	.16	.10	.006	.116	.005	.005	.067
	Panicum	1	.01	.10	.006	.005	.005	.005	.003
	Sporobolus	1	.01			.005			
	Centrus	0	0	.20	.006	0	.01	.005	0
	Tidestroemia	0	0	.20	.006	0	.01	.005	0
	Cassia	34	.24			.179			.103
	Oenothera	9	.06			.005			.027
	Ambrosia	2	.01			.001			.006
	I. stolonifera	3	.02	.40	.02	.002	.02	.016	.009
	AL*	68	.49			.036			.206
	BG*	144			.88			.76	
	GL*	13			.08			.04	
						= .349			= .422

NOTRAF 10-7-75 (cont.) POINT FRAME

Transect	Species	Composition # Ind.	% Foliar	% Basal	% Ground	Density 210' Foliar	Basal	Ground	330' Foliar to 0 MSL
580 S	Cyperus	3	.05			.014			.009
	Tidestroemia	1	.02			.005			.003
	Cassia	3	.05			.014			.009
	Oenothera	25	.43	.40	.01	.119	.009	.005	.076
	I. stolonifera	14	.24	.60	.03	.067	.014	.014	.042
	AL*	12	.21			.057			.036
	BG*	98			.90			.47	
	GL*	7			.06			.03	
						= .279			= .175

* AL = aerial litter; BG = bare ground; GL = ground litter

NOTRAF

POINT FRAME

Transect	Species	Composition				Density			
Transect	Species	# Ind.	% Foliar	% Basal	% Ground	230' Foliar	Basal	Ground	360' Foliar to 0 MSL
400 S	Eragrostis	1	.03			.004			.003
	Oenothera	8	.23	.14	.005	.035	.009	.004	.022
	Erigeron	0		.29	.005		.017	.004	
	I.stolonifera	16	.46	.29	.009	.069	.017	.013	.044
	I.pes-caprae	2	.06	.21	.014	.009	.013	.009	.006
	Sesuvium	6	.17	.07	.005	.026	.004	.004	.017
	AL*	2	.06			.009			.006
	BG*	172			.80			.75	
	GL*	35			.16			.15	
						= .152			= .093
						220'			360'
200 S	Uniola	9	.15	.125	.008	.041	.004	.004	.025
	Sporobolus	2	.03			.009			.006
	Tidestroemia	6	.10	.125	.008	.027	.004	.004	.017
	Croton	14	.23	.625	.024	.064	.023	.014	.039
	Oenothera	6	.10	.125	.008	.027	.004	.004	.017
	I. stolonifera	4	.07			.018			.011
	AL*	19	.32			.086			.053
	BG*	108			.87			.490	.30
	GL*	10			.08			.045	.03
						= .272			= .168

NOTRAF

POINT FRAME

Transect	Species	# Ind.	Composition % Foliar	% Basal	% Ground	Density 196' Foliar	Basal	Ground	360' Foliar to 0 MSL
0	Uniola	33	.185	.44	.02	.168	.02	.020	.092
	Spartina	11	.06			.056			.031
	Eragrostis	2	.01			.010			.006
	Paspalum	10	.06			.051			.028
	Leptoloma	2	.01			.010			.006
	Tidestroemia	1	.005			.005			.003
	Cassia	15	.08			.076			.042
	Oenothera	1	.005	.11	.005	.005	.005	.005	.003
	Erigeron	7	.04	.33	.01	.036	.015	.010	.019
	I. stolonifera	8	.04	.11	.005	.041	.005	.005	.022
	Amaranthus	1	.005			.005			.003
	AL*	87	.49			.444			.242
	BG*	178			.855			.908	.494
	GL*	23			.11			.117	.064
						= .907			= .557
					Total	4.942		Total	2.171

*AL = aerial litter; BG = bare ground; GL = ground litter

VEHTRAF 23/10/75 POINT FRAME

	Species	Family
Grasses:	Uniola paniculata	Graminae
	Spartina patens	Graminae
	*Panicum amarum	Graminae
Forbs:	Ipomoea stolonifera	Convolvulaceae
	Croton punctatus	Euphorbiaceae
	Cassia fasiculata	Leguminosae
	Ipomoea pes-caprae	Convolvulaceae
	Tidestroemia lanuginosa	Amaranthaceae
	Oenothera drummundii	Onagraceae
	**Euphorbia ammanoides	Euphorbiaceae

*1.0%
** .5%

VEHTRAF 10-23-75 POINT FRAME

Transect	Species	Composition #Ind.	% Foliar	% Basal	% Ground	Density 150' Foliar	Basal	Ground	360' Foliar to 0 MSL
2.3	Uniola	1	.05	.2	.01	.007	.007	.007	.003
	Spartina	2	.09			.013			.005
	I. stolonifera	10	.48	.4	.01	.067	.013	.007	
	Tidestroemia	0	0	.4	.01		.013	.007	
	AL*	8	.38			.05			.02
	BG*	92			.96			.61	
	GL*	1			.01			.007	
						= .137			= .058
						230'			360'
2.0	I. stolonifera	10	.43	.44	.05	.04	.02	.02	.03
	Croton	6	.26	.44	.025	.03	.02	.009	.02
	Oenothera	6	.26	.11	.01	.03	.004	.004	.02
	AL*	1	.04			.004			.003
	BG*	69			.88			.3	
	GL*	2			.025			.009	
						= .104			= .073
						200'			390'
1.7	Spartina	6	.14			.003			.015
	I. stolonifera	1	.02	.67	.01	.005	.01	.005	.002
	Croton	28	.67	.33	.01	.14	.005	.005	.072
	AL*	7	.17			.035			.018
	BG*	98			.98			.049	
	GL*	0			.00			0	
						= .183			= .107

VEHTRAF 10-23-75 (cont.) POINT FRAME

Transect	Species	#Ind.	% Foliar	% Basal	% Ground	Density 240' Foliar	Density Basal	Density Ground	420' Foliar to 0 MSL
1.4	Uniola	12	.11			.05			.028
	I. stolonifera	3	.03	.57	.03	.13	.016	.016	.007
	Croton	32	.30	.43	.01	.15	.012	.008	.076
	Cassia	37	.34			.10			.080
	AL*	24	.22						.057
	BG*	123			.90			.51	
	GL*	8			.06			.03	
						= .44			= .256
						110'			410'
1.0	Uniola	2	.05			.02			.005
	I. stolonifera	21	.50	.78	.04	.19	.06	.04	.051
	Croton	13	.31	.22	.01	.12	.02	.009	.032
	AL*	6	.14			.054			.015
	BG*	93			.90				
	GL*	5			.05				
						= .384			= .103
						170'			360'
0.6	Uniola	17	.24	.2	.007	.10	.012	.006	.047
	I. stolonifera	9	.13	.4	.03	.05	.023	.023	.025
	I. pes-caprae	11	.15	.4	.02	.06	.023	.018	.030
	Cassia	8	.11			.05			.022
	AL*	26	.37			.15			.072
	BG*	111			.88			.65	
	GL*	7			.055			.04	
						= .41			= .196

*AL=aerial litter; BG=bare ground; GL=ground litter

VEHTRAF

10-8-75

Transect	Species	Composition #Ind.	% Foliar	% Basal	% Ground	POINT FRAME Density 240' Foliar	Basal	Ground	385' Foliar to 0 MSL
1000N	Spartina	1	.06	.22	.01	.004	.008	.004	.002
	I. stolonifera	3	.18	.22	.01	.012	.008	.004	.008
	I. pes-caprae	11	.65	.56	.04	.096	.021	.021	.028
	AL*	2	.12			.008			.005
	BG*	105			.85			.437	
	GL*	11			.09			.046	
						= .07			= .043
						220'			420'
800N	I. stolonifera	8	.80	.75	.03	.036	.014	.009	.019
	Tidestroemia	1	.10	.25	.01	.004	.004	.004	.002
	AL*	1	.10			.004			.002
	BG*	66			.96				
	GL*							.30	
						= .044			= .023
						235'			430'
600N	Uniola	9	.12			.038			.021
	I. stolonifera	5	.07	.25	.02	.021	.013	.013	.012
	Croton	37	.50	.75	.02	.157	.038	.013	.086
	Cassia	17	.23			.072			.039
	AL*	6	.08			.025			.014
	BG*	99			.82			.421	
	GL*	16			.13			.068	
						= .313			= .171

VEHTRAF 10-8-75 (cont.) POINT FRAME

Transect	Species	#Ind.	% Foliar	% Basal	% Ground	230' Foliar	Basal	Ground	430' Foliar to 0 MSL
		Composition				Density			
400N	Spartina	3	.11			.013			.007
	Panicum	1	.035			.004			.002
	I. stolonifera	9	.32	.82	.06	.039	.039	.030	.021
	Croton	4	.14	.09	.01	.017	.004	.004	.009
	Tidestroemia	9	.32	.09	.01	.039	.004	.004	.021
	AL*	2	.07			.009			.005
	BG*	91			.87			.396	
	GL*	5			.05			.022	
						= .121			= .065
						185'			370'
200N	Uniola	4	.10			.022			.011
	Spartina	5	.12			.027			.013
	I. stolonifera	23	.56	.90	.055	.124	.049	.032	.062
	Croton	1	.02	.10	.009	.005	.005	.005	.003
	Tidestroemia	1	.02			.005			.003
	AL*	7	.17			.038			.019
	BG*	98			.91			.53	
	GL*	3			.03			.016	
						= .221			= .111

*AL=aerial litter; BG=bare ground; GL=ground litter

VEHTRAF 10-9-75 POINT FRAME

Transect	Species	#Ind.	Composition % Foliar	% Basal	% Ground	Density 190' Foliar	Basal	Ground	350' Foliar to 0 MSL
Ø	Uniola	18	.37	.08	.01	.09	.005	.005	.051
	I. stolonifera	12	.25	.25	.01	.06	.015	.02	.034
	I. pes-caprae	9	.19	.67	.03	.05	.042	.01	.026
	Cassia	4	.08			.02			.011
	Euphorbia	2	.04			.01			.006
	AL*	3	.06			.015			.008
	BG*	122			.96			.64	
	GL*				0				
						= .245			= .136
						Total 2.672			Total 1.342

*AL=aerial litter; BG=bare ground; GL=ground litter

SHELL	21/10/75	POINT FRAME

	Species	Family
Grasses:	Uniola paniculata	Graminae
	Heterotheca subaxillaris	Compositae
	Cassia fasiculata	Leguminosae
	Croton punctatus	Euphorbiaceae
	Ipomoea pes-caprae	Convolvulaceae

PEDTRAF	9/10/75	POINT FRAME

	Species	Family
Grasses:	Paspalum monostachyum	Graminae
	Uniola paniculata	Graminae
	Cassia fasiculata	Leguminosae
	Croton punctatus	Euphorbiaceae
	Tidestroemia lanuginosa	Amaranthaceae
	Amaranthus greggii	Amaranthaceae
	Ipomoea stolonifera	Convolvulaceae
	Euphorbia ammanoides	Euphorbiaceae
	Ipomoea pes-caprae	Convolvulaceae
	Sesuvium portulacastrum	Aizoceae
	Oenothera drummundii	Onagraceae

			Composition			POINT FRAME Density			
SHELL									
	Species	#Ind	% Foliar	% Basal	%Ground	203' Foliar	Basal	Ground	340' Foliar to 0 MSL
10-21-75	Uniola paniculata	4	8	50	1	.019	.015	.005	.012
	Croton punctatus	3	6			.015			.015
	Cassia fasiculata	6	12			.030			.018
	I. pes-caprae	1	2	17	1	.005	.005	.005	.003
	Heterotheca subaxillaris	11	22	33	1	.054	.010	.005	.032
	AL*	25	50			.123			.074
	BG*	1			96			.42	
	GL*	85			1			.005	
	Total					= .246	= .030		= .154
PEDTRAF									
						222'			(NONE)
10-9-75	Uniola paniculata	9	5	20	.5	.041	.009	.004	
	Paspalum monostachyum	10	6			.045			
	Tidestroemia lanuginosa	17	10			.076			
	Croton punctatus	27	16	30	1.0	.122	.014	.009	
	Cassia fasiculata	56	33			.25			
	Euphorbia ammanoides	5	3			.023			
	Oenothera drummundii	1	.5			.005			
	I. pes-caprae	4	2	20	1.0	.018	.009	.009	
	I. stolonifera	6	4			.027			
	Amaranthus greggii	8	5	20	.5	.036	.009	.004	
	S. portulacastrum	4	2	10	.5	.018	.004	.004	
	AL*	21	12.5			.095			
	BG*	184			95			.83	
	GL*	3			1.5				
	Total					= .756			

*AL=aerial litter; BG=bare ground; GL=ground litter

APPENDIX B

Beach elevations, widths, and volumes to MSL

PADRE ISLAND NATIONAL SEASHORE

Avg. Elevations/transect (to 0'MSL)

Trans.	Ave. Beach El.	Ave. Veg. El.	Ave. Bare Beach El.	Veg. Distance	Transect Distance	Veg. Vol.	Bare Vol.	Totl. Vol.
Not. 0	4.72	6.39	2.63	200'	360'	1278	421	1699
Not. 200S	5.19	6.72	2.80	220'	360'	1478	392	1870
Not. 400S	4.72	6.01	2.45	230'	360'	1382	319	1701
Not. 580S	5.18	6.61	2.68	210'	330'	1388	322	1710
Not. 620S	5.12	7.27	2.2	190'	330'	1381	308	1689
Not. 800S	4.75	6.40	2.47	190'	345'	1216	383	1599
Not. .4 mi.	4.46	6.34	2.26	200'	370'	1268	384	1652
Not. .8 mi.	4.99	7.32	2.66	200'	400'	1464	532	1996
Not. 1.2 mi.	4.20	5.96	2.44	240'	480'	1430	586	2016
Not. 1.6 mi.	4.42	6.55	2.01	220'	415'	1441	392	1833
Not. 2.0 mi.	4.34	6.24	2.22	200'	380'	1248	400	1648
Not. 2.4 mi.	4.59	6.71	2.37	210'	410'	1409	474	1883
m =	4.72	= 6.54	= 2.43	= 209'	= 378'	= 1365	= 409	= 1779
s =	.33	= .43	= .23	= 15.6	= 43	= 90	= 84	= 135
Veh. 0	5.18	7.64	2.26	190'	350'	1452	362	1814
Veh. 200N	5.19	7.80	2.58	185'	370'	1443	477	1920

PADRE ISLAND NATIONAL SEASHORE (cont.)

Trans.	Ave. Beach El.	Ave. Veg. El.	Ave. Bare Beach El.	Veg. Distance	Transect Distance	Veg. Vol.	Bare Vol.	Totl. Vol.
Veh. 400N	5.16	7.20	3.22	210'	430'	1512	708	2220
Veh. 600N	5.68	8.42	2.38	235'	430'	1979	464	2443
Veh. 800N	4.10	5.82	2.21	220'	420'	1280	442	1722
Veh. 1000N	4.87	6.24	2.61	240'	385'	1498	378	1876
Veh. .6 mi.	5.86	8.22	3.74	170'	360'	1397	711	2108
Veh. 1.0 mi.	4.63	8.71	3.14	110'	410'	958	942	1900
Veh. 1.4 mi.	6.15	8.25	3.35	240'	420'	1980	603	2583
Veh. 1.7 mi.	6.28	8.92	3.50	200'	390'	1784	665	2449
Veh. 2.0 mi.	4.78	6.35	2.01	230'	360'	1461	261	1722
Veh. 2.3 mi.	4.61	7.17	2.78	150'	360'	1075	584	1659
m =	5.21	= 7.56	= 2.81	= 196'	= 391'	= 1485	= 550	= 2035
s =	.67	= 1.02	= .56	= 40	= 30	= 313	= 189	= 319
Shell	4.91	7.39	4.02	90'	340'	665	1005	1670
Pedtraf.	-	7.04	-	220'	-	1549	-	-

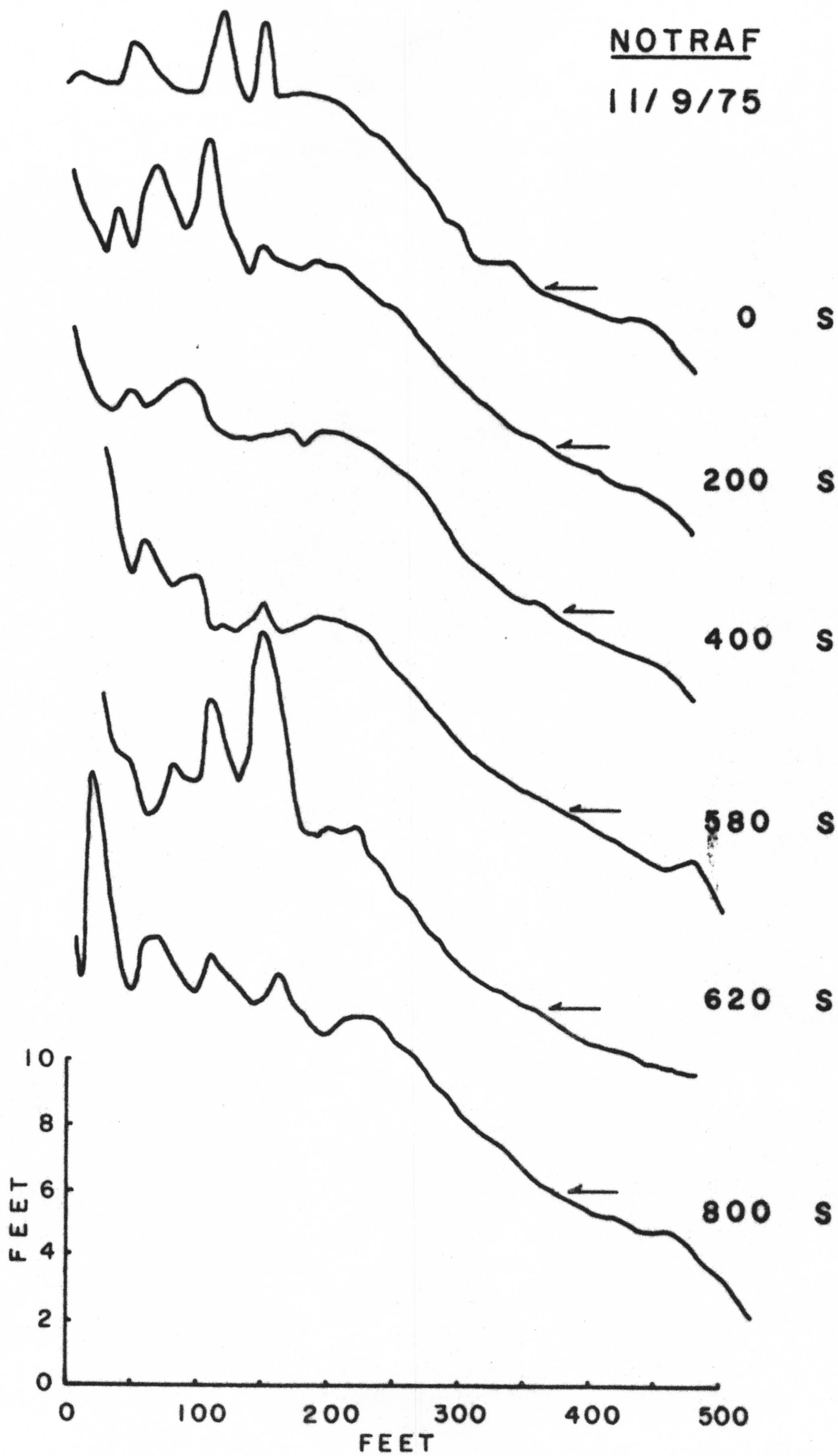
Sand Storage above "hurricane beach"

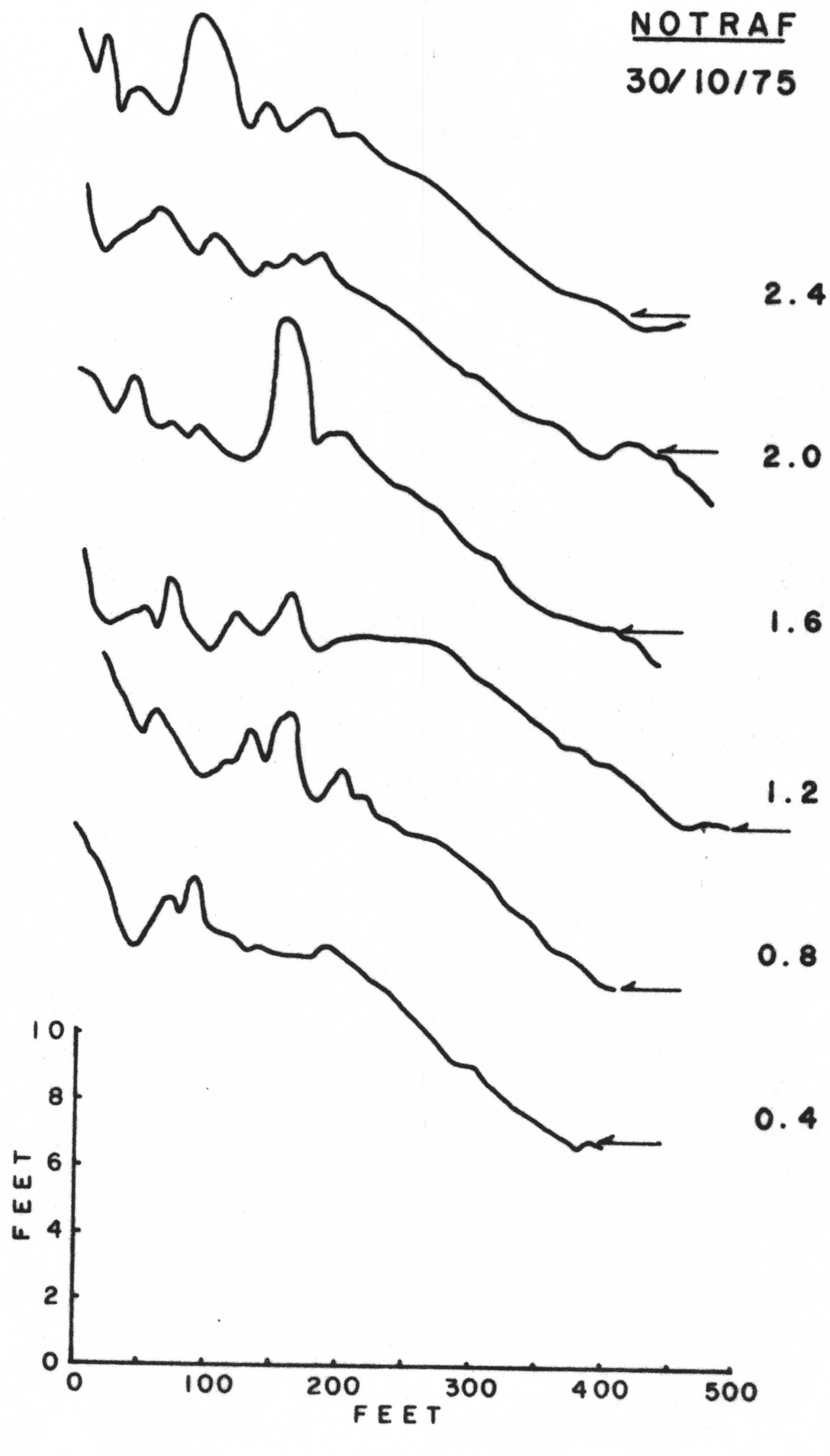
ST.	O-Berm. Volume	O-Veg. Volume	Veg.-Berm.
Not. 0	466	372	94
Not. 200S	461	460	1
Not. 400S	351	351	0
Not. 580S	689	654	35
Not. 620S	970	854	124
Not. 800S	722	676	46
Not. .4 mi.	738	710	439
Not. .8	892	892	0
Not. 1.2	648	284	364
Not. 1.6	289	216	73
Not. 2.0	432	432	0
Not. 2.4	736	318	418
	m = 616 s= 214	m = 518 s= 229	m = 133
Veh. 0	681	549	132
Veh. 200N	644	611	33
Veh. 400N	1077	565	512
Veh. 600N	946	557	389
Veh. 800N	737	217	520
Veh. 1000N	833	241	592
Veh. .6 mi.	927	662	265
Veh. 1.0	656	435	221
Veh. 1.4	1283	194	1089
Veh. 1.7	1065	-60	1125
Veh. 2.0	1132	-531	1663
Veh. 2.3	670	-131	801
Shell 200	532	207	325
Pedtraf. 265	906	702	204
	m = 1007	m = 410 s= 285	m = 656

APPENDIX C

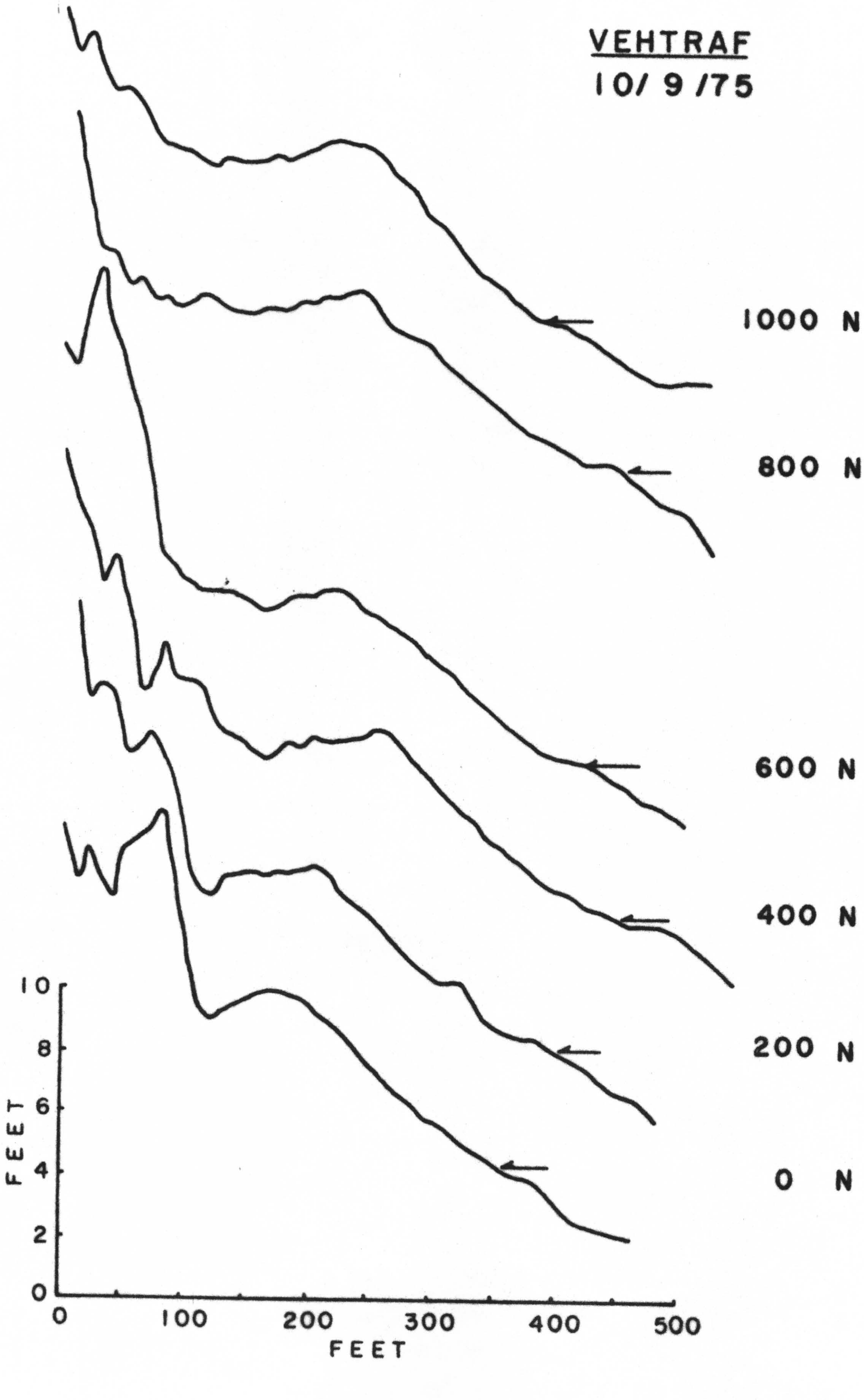
Beach Profiles
September - October 1975

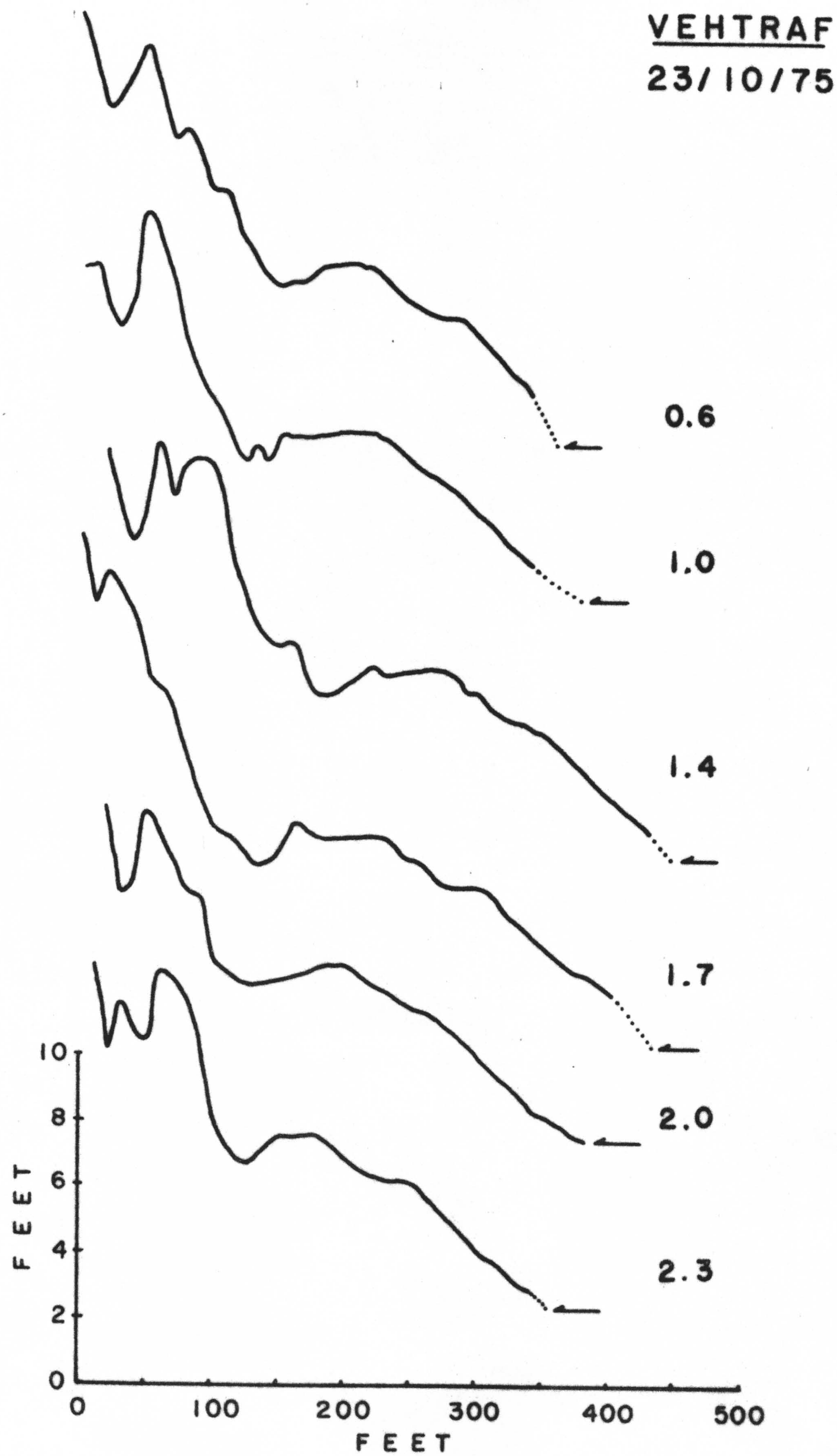
Numbers followed by the letters N or S indicate distance in feet north or south, respectively, of the original, 1974 transect line. Other numbers indicate distance in miles from the original transects. Dates of elevation surveys are given as day/month/year.


NOTRAF
11/9/75
0 S
200 S
400 S
580 S
620 S
800 S
10
8
6
4
2
0
FEET
0
100
200
300
400
500
FEET

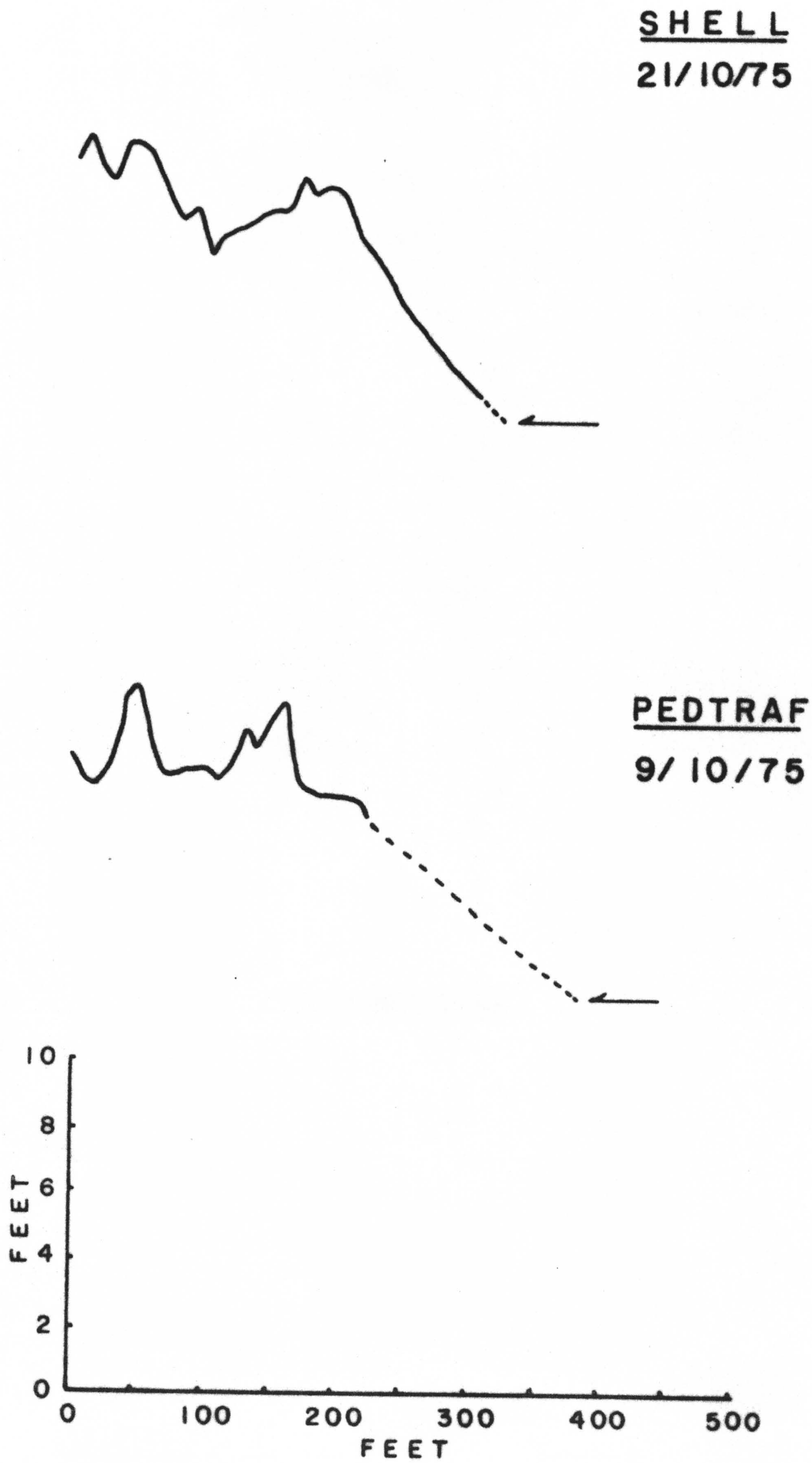


NOTRAF
30/10/75
2.4
2.0
1.6
1.2
0.8
0.4
10
8
6
4
2
0
FEET
0
100
200
300
400
500
FEET


VEHTRAF
10/ 9 /75
1000 N
800 N
600 N
400 N
200 N
0 N
FEET
0
2
4
6
8
10
0
100
200
300
400
500
FEET



VEHTRAF
23/10/75
0.6
1.0
1.4
1.7
2.0
2.3
10
8
6
4
2
0
FEET
0
100
200
300
400
500
FEET


SHELL
21/10/75
PEDTRAF
9/10/75
10
8
6
4
2
0
FEET
0
100
200
300
400
500
FEET